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TECHNICAL MERITS AND LEADERSHIP IN FACILITY MANAGEMENT

By

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Executive Summary.

After almost ten years of experience and formal education in design, construction, and facility operations and maintenance, the challenges and complexity of facility management still seem overwhelming and intangible. This document explores those complexities and challenges, and presents several philosophies and strategies practiced in facility management. The document is divided into six chapters; the introduction, facility management and leadership, building systems, facility operations, facility maintenance strategies, and the conclusion and final analysis. Although real estate planning is a major function of the facility manager, it is not discussed here.

The first chapter presents the introduction to facility management. The second chapter presents management and leadership philosophies with discussion on various Total Quality Management (TQM) programs and a few of the more recognized standards and awards; Deming, ISO 9004 series, the Malcolm Baldridge National Quality Award, Six Sigma and Qualtec's "world-class quality service". The third chapter presents basic descriptions of the building systems with the most direct impact of the facility capabilities, the operators, and the technicians. Chapter four discusses facility operations as paramount to the smooth operations of the organization and the physical environment of the building occupants; including space planning, custodial services, energy management, physical security, and disaster preparedness. Chapter five presents factors influencing maintenance strategies, such as the traditional scheduled maintenance, reliability centered maintenance and outsourcing. From these factors a tailored maintenance plan may be developed to best

suit the organization and mission. The final chapter summarizes the document and stresses that a comprehensive plan and program are imperative to successfully achieving the facility management mission.

The document is based on several years experience combined with graduate course work, and research of numerous publications including the Internet. The personal experience is based on small to medium military facilities with multiple tenant organizations ranging from 60 to 500 military and civilian personnel. The facilities square footage ranged in size from 20,000 to 200,000 square feet, and were located in several states and foreign countries with significant geographical, climatic and cultural differences. The facility mission supported aviation operations and facilities, large communication centers, training complexes, high level executive offices, and common spaces and administrative functions. The scope of work involved new construction, renovation and alterations projects, relocations, and recurring maintenance and repair programs. Although much of the document is based on military facilities, most facility managers will agree that the subject matter involved does not vary greatly from one physical facility to another whether the facility is industrial, government or institutional.

CHAPTER 1: INTRODUCTION:

1.1 Background.

The following quote is an excellent statement of what facility management is:

"The practice of coordinating the physical workplace with the people and work of the organization; integrates the principles of business administration, architecture, and the behavioral and engineering sciences."

- David G. Cotts and Michael Lee 1992 (1:3)

The "facility management" profession and term began to take shape in the late 1970's and early 1980's. This is not to say that the facility engineering/management function did not take place prior to that, it was just done under different names such as public works, postengineering or plant administration. Numerous professional organizations, such as International Facility Management Association (IFMA), the American Institute of Plant Engineers and others were founded and expanded. In addition, many companies began advertising facility management consultant services and began recruiting facility managers/engineers. Thus the facility management profession and practice took on a new character and more significant role.

Much of this can be attributed to the societal and technological advances (2:8). The organizational cultural changes from TQM programs, technological advances in computers, construction materials and techniques, and new governmental regulations initiated a remarkable transformation of the facility, the work place and living spaces. Just a few of the technological advances are local area networks (LAN's), telecommunications, teleconferencing, new furniture philosophies, lighting, and smart buildings. The

construction improvements include complex and integrated structural, electrical, and mechanical systems and a vast number of new materials. The new regulations include the areas of energy, environmental, safety, fire, and disabled workers. Along with this, there were huge increases in global market competition and population. The result is that the last few decades have seen a major transformation in the cultures, the philosophy, and the physical environments of corporations and agencies everywhere.

This major restructuring is felt by facility managers and executives alike. Not only is improving the work environment and productivity of an organization important, facility management is one of the major expenses in most organizations. The Department of Defense alone has over $500 Billion invested in facilities (3:1). To stay competitive, organizations must become more productive and efficient. All of the previously mentioned factors combine into a complex cycle of events that are only touched upon in this document.

1.2 Current trends.

Today quality management programs are common place, new technologies are announced weekly, natural disasters occur like clock work, increased churn rates -turnover of employees, and "right sizing" are felt everywhere. With these events, new challenges are presented to the organization and the facility manager (FM) for the strategic implementation into the work place. Yet this is just the tip of the iceberg for the FM; there is still the day-to-day challenges of the maintenance and repair activities, personnel

management, budget shortfalls, and a host of activities bidding for the FM's time and leadership. Change is inevitable, as Heraclitus stated:

"Nothing endures but change"

- Heather McLean Wiederhoef 1997 (4:6)

The facility management business is reactive by nature, a system or piece of equipment fails, the roof leaks, the company purchases new equipment, develops a new product, or makes changes in the personnel and work place. A strategic plan is essential to successfully achieve the FM mission. Without a strategic plan, the facility management program is jeopardized, often leading to potential failures in the facility infrastructure and operations that can cripple an organization overnight. Facility or equipment failures, not caught early, can be exponentially more expensive, complex and disruptive. This fact is not lost on the corporations, and is, in part, what leads to the need for new associations, formal educational programs and professional development.

One of the associations founded to meet this challenge is the IFMA. Since its formation in 1980, IFMA has grown to 14,400 members throughout the world (5). Like IFMA, many organizations have attempted to capture the vast diversity of the competencies and challenges required in facility management. The lists of expected professional competencies commonly expected of an facility manager range from seven to fourteen depending on the source. Below are two examples that illustrate the diversity:

IFMA(6:4):

- Communication
- Facility Function
- Quality Assessment and Innovation
- Human and Environmental Factors
- Operations and Maintenance
- Planning and Project Management
- Finance
- Real Estate

Building Service Institute of New York (BSI) (7:1):

- Electrical Systems
- Economics
- Environmental Management
- Maintenance
- Mechanical Systems
- Administrative and Supervision
- Civil and Structural

IFMA has also established professional certification program that test the above competencies. Another certification program is established specializing in hospital facility management. Mastering the multiple engineering disciplines, or at least understanding them, is an accomplishment enough; but adding deferred maintenance, budget deficiencies, critical time constraints, and personnel/personality issues both with upper management and the facility workforce, and this profession becomes mystifying.

Along with the formation of the IFMA and many more organizations, there is now a professional degree in facility management offered at many colleges and universities. The professional certification processes, improved educational opportunities and work of the professional associations are improving the facility management community and our ability to meet the challenges of today, and tomorrow.

CHAPTER 2: FACILITY MANAGEMENT AND LEADERSHIP

2.1 Introduction.

There are volumes of information on the definition, styles, principles and philosophies of management and leadership, but there is a distinct difference between management and leadership. Management is the process to organize, budget, coordinate and execute the activities for an organization. Leadership is the art of successfully achieving that mission through direction, guidance and actions that inspire and persuade people to accomplish the mission.

"Managers plan activities, organize appropriate structures, and control resources, but the primary role of a leader is to influence others voluntarily to seek defined objectives (preferably with enthusiasm!). Managers hold formal positions, whereas anyone could use their informal influence while acting as a leader. Managers achieve results by directing the activities of others, whereas leaders create vision and inspire others to achieve this vision and to stretch themselves beyond their normal capabilities."

■ *Newstrom/Davis 1993(8:228)*

One critical measure of success in facility management is customer service. The TQM and quality standards in the following sections provide excellent techniques and measurements for a quality centered organization to meet this objective. However, in a facility department, the work force is typically comprised of technical experts with less practiced "people skills" which can diminish customer service and satisfaction. Introducing new cultural philosophies and programs can be very difficult. To overcome the inherent

resistance to change, inspirational leadership with exceptional communication skill will be required. The focus in this document is for a leader to explore his/her people's needs, desires, and goals; so that they know their people, and what motivates them. Far to often, the technical experts learn to be reactive and focus only on the skills required. The experts fail to establish goals and objectives for the future. A leader who can develop a quality centered program with visionary personnel, will tremendously improve the productivity and quality of the organization.

2.2 Management - Total Quality Management.

There are numerous TQM initiatives and programs, not all successful. Each organization must research to find the best program to fit the culture of its organization. However, the TQM program itself may lead to dramatic changes in the daily activities and philosophies, ultimately changing the culture of the organization. The following quote presents an excellent description of quality maintenance and engineering:

A quality vision focuses on operational efficiency, increasing productivity and lowering cost. To successfully implement a quality system, it is necessary to utilize appropriate technology, establish procedures, train employees and audit, and follow-up as an ongoing learning process. Such a process benefits the organization, its customers and employees.

In facility management planning, the service we provide to our internal and external customer is organizing and tracking for the purpose of improving and maintaining high-performance buildings and equipment. Building and performance is linked directly to operational costs, as well as to customer satisfaction. Providing an aesthetically-pleasing, safe, reliable and secure environment that is cost efficient and increases productivity is our facility management function."

- Sofia Hilentzaris 1997 (9:13)

The practice of TQM focuses on the involvement of every employee to continuously find improvements in every aspect of the organization. With this involvement, the employees can find rewards in the ownership and empowerment to make a difference. Furthermore, if the ideas come from employees, or with their input, the chances of a change being thoroughly implemented, tested and accepted is much higher. Some changes are inevitably going to be less successful than others, but the creative and innovative ideas must be nurtured and explored for the continuous improvement cycle to be successful. If we are to maintain the highest quality of life, a program of total quality improvement must be sustained, regardless of the title applied.

2.2.1 The Deming Prize.

W. Edwards Deming was the leader of the TQM initiatives in the restructuring of the Japanese industry in 1951, perhaps a key reason that Japan vaulted to the top of international markets and competition. The following is a condensed version of the 14 Points for Management from Deming's book Out of Crisis (10):

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.

2. Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier of any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.

6. Institute training on the job.

7. Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortation only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11. a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.

    b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.

12. a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.

    b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual merit rating of management by objective.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

The Deming principles can be very powerful and effective when applied in the appropriate culture and organization. It is worth mentioning, however, that the most opportune time for any change is before maturity and tradition are deeply implanted. Even though

tradition in Japan is far more entrenched than in the US, the industrial explosion had just begun there. Application into the US industries and agencies is more difficult and not directly comparable to the Japanese culture and tradition.

2.2.2 International Organization for Standardization - ISO 9000.

The ISO 9000 is actually a certification process with a series of three levels of certification and two guidelines (11). The 9000 and 9004 series are guidelines and the 9001, 9002 and 9003 certifications. The ISO 9004 series standardization organization is made up of representatives from over a 100 countries, primarily the European countries. The ISO 9000 series actually represents a stamp of approval for the consumers of the company based on the company's quality programs. With the global market competition, the vast number of suppliers, and complexities of products and services the traditional comparison methods for finding the "best buy" are insufficient. The ISO 9000 series provides a customer an alternative focused on the supplier's quality system vice the product or service. Like Deming ISO established guiding principles, but only eight. There are 20 criteria in the application for the ISO 9001-

"... from how purchase orders are completed, how employees are trained, and how quality records are maintained and disposed of, to how internal quality audits are performed, how subcontractors are evaluated, and how contracts are received and customer requirements met .... and an on-site audit team ... determines whether the facility is in compliance with the ISO 9000 criteria."

- Barbara L. Vergetis Lundin1997 (12:2)

There are obvious internal benefits of increased efficiency and productivity, positive changes in corporate culture, greater quality awareness, and reduced scrap and rework through training employees to produce the same work, the same way every time. External benefits include higher perceived quality, improved customer satisfaction, a competitive edge, reduced customer audits and increased market shares. One of the problems with this certification is the cost, depending on the size and complexity of an organization, the cost could be in excess of $150,000. However, in big business, realizing small percentages of efficiency can generate significant returns on investment.

2.2.3 Malcolm Baldridge National Quality Award.

This award is the most coveted quality award in the United States. It was established in 1987 by the US government, and has three categories; manufacturing companies, service companies and small business. The award is based on the Presidential Award criteria. A synopsis of the seven criteria are presented below (13):

a) Leadership - visionary inspirational leadership.

b) Information and Analysis - to support improved customer satisfaction, products, services, and processes.

c) Strategic Quality Planning - short term and long term developing the planning process and specifics of the plan itself encompassing all aspects and interdependencies.

d) Human Resource Development and Management - both personal and organization development with education, performance, recognition, well-being and satisfaction.

e) Management of Process Quality - systematic methods to continually improve quality and operational performance.

f) Quality and Operational Results - the task of measuring and quantifying results and bench marking with other competitors.

g) Customer Focus and Satisfaction - in terms of absolute levels and trends.

2.2.4 Six Sigma Quality Standard.

The Six Sigma Quality Standard began in 1985, when a Motorola quality professional presented a paper describing the relationship of a products early-life field reliability to the frequency of repair during the manufacturing process. The basis of Six Sigma is to do it right the first time, at the extreme. Achieving Six Sigma, requires that less than three parts per million have defects. There is much debate on achieving this extreme level of quality and the successes just in the pursuit of it. It is believed by some that this standard is unachievable, but the pursuit of it still provides substantial rewards in quality. (14)

2.2.5 World-Class Service Quality Management System

One last discussion of quality management is the "World-Class Quality" as described by Qualtec Quality Services, Inc. Qualtec has four basic principles to their approach in a world-class service quality management system; customer satisfaction, respect for people, management by fact and continuous improvement. Their approach involves three components; policy management, process management and quality teams. As for the specifics of the system, it is worth consulting with the company itself and reading their pamphlets and publications. This is one of the only companies outside of Japan to ever be

recognized and awarded the Deming Prize, and their fantastic programs are best presented by Qualtec. (15)

2.3 Leadership, the human element.

This chapter will not get into the philosophical debate on whether leaders are genetic or grown through experience and training, other than to say it may be both. Some people choose not to take leadership roles, requiring demanding responsibilities and challenges, others jump at the opportunity to challenge themselves and excel. What this points out is that there are different personalities and levels of personal desires and motivations.

There are several types of leaders, three broad types of skills, and styles employed. The types of leaders can be classified in various ways, the most obvious being situational and formal. A major difference is that the situational leader may only be so in certain groups or functions, where the formal leader will almost always assert themselves in every endeavor. The skills used by leaders are technical skill, human skill and conceptual skill. The amount of each skill level varies when climbing the corporate ladder. The conceptual skill become paramount at higher levels and technical skill becomes less critical, or at least more dependent on those supporting them, where the human skills are required at every level. The styles vary from consideration leadership to structure leadership. The perspective fluctuates from concern for the people to concern for production, or some combination between. There is also the leadership approaches: free-rein, autocratic and participative.

One last factor is the positive or negative outlook of people. McGregor's Theory X and Theory Y about the alternative assumptions about employees is important. The Y Theory assumes the best in people, that they want to do a good job and not fail, and the X Theory assumes people must be forced and coerced to work. It is important to evaluate your own personal skills and style, how they fit into the organization and more importantly how your people will best respond to your leadership character. The best leader is believed to be positive, participative and considerate. (16)

2.3.1 Communication

Communication may be the most essential element in our lives. Effective communication is imperative to good relationships at home, in the community, at work and at play. It is so important to us that we use it as a form of punishment, solitary confinement in penal systems and grounding or time outs to our children. This element, without a doubt, has the strongest ability to positively or negatively impact those around us and the workplace. "Communication must flow in both directions and can come in four ways: listening, talking, writing, and body language. Communication must be on two levels, thoughts and feelings." (17)

It is imperative that the individual and the organization practice good communication skills and continually strives to improve the environment. This is why TQM is so effective in some organizations, the TQM program improves communications, which improves interpersonal relations, and provides better understanding of functions the interdependencies. The individual skills of communication are intricately linked and

affected by the environment in which communication takes place. Good leadership must exercise good communication skills and create the optimal work place environment which removes factors limiting creativity, innovation and communication.

The environment for interaction is only as limited as the leader makes it. Opportunities such as a social outing, privacy of an office, the shop floor, or just passing in the hallways offer a few creative situations to interact. Using the office can take on several variations and personalities as well. Placing a visiting person on the other side of the desk, can give the distancing effect and opposing forces impression, which in some instances may be the desired effect. Having the person just partially separated by the corner of the desk, or no obstacles, can give a more open and comfortable atmosphere. Physical barriers can create psychological barriers. Some people have a very large comfort zone, or personal space, so they prefer the distance be fairly large.

There are many factors and distractions that can negatively impact communication. A few examples of the physical and psychological distractions are as follows: hands in the pockets and jingling keys or change when standing in front of a group, reading or fussing with something on the desk when talking to someone, or talking from behind a computer. To be effective you must give your undivided attention and maintain eye contact with that person and not let distractions deter you.

One of the single most important factors is perception. Miss perception can cause more failures in the interpersonal dealings than any other factor. If it is perceived that you are not listening and they are wasting their time, you will lose their commitment and respect. Situational awareness is vital to understanding perception and communication.

The situations in which customers are irate because of faulty equipment they are not generally interested in excuses or long explanations, they just want the equipment fixed. The customer may be experiencing significant pressures from the impacts of the failed equipment. The only answer that will satisfy them is properly running equipment. Poor communication in these situations can easily escalate with long term results. It can take ten acts of kindness to erase one such bad experience.

The last point on communication is to exercise it at every opportunity and make opportunities. Many employees are elated with just chatting with the boss. The fact they were recognized and the boss took the time to say hello can go a long way in making some people important and motivated. Job recognition and appraisal are important, but are not the only opportunity or basis to recognize and communicate with people. Good leaders will make it a requirement to get out of the office visit the jobs, people and spaces, and break down the barriers and layers restricting open and honest communication.

2.3.2 Mission Statements

A mission statement is one of the most important aspects of leadership and communication. A good mission statement provides the principles, values and expectations of the organization. Clarity of purpose and mission is very stimulating and reassuring to people. The mission statement is not limited to the overall organization, each department can create a mission and vision statement. One of the best applications of TQM is communication and the creation of flow charts to visualize the processes in a department. Developing a flow diagram can create better understanding of the roles,

relationships, and interdependencies. Mission and vision statements can and should be created and combined to include the people, the organization, and the processes.

2.3.3 Goal Setting, Rewards and Objectives.

Our most important asset is our people. To best lead them, it is not sufficient to just understand our leadership style, the impact, and our communication techniques, we must know what motivates and satisfies them. Capturing and understanding the concerns and motivations of the people can be used and merged to enhance the department's and organization's mission. Time must be invested in the people to learn and establish their goals - needs and desires - and marry them to the organization. Many times an employees' needs can be directly linked and satisfied within the organization. For example, an employee may desire better education and skills. The organization desires continuous improvement in efficiency in the processes and personnel. Providing additional training and education achieves both. Another example might be an employee desiring a transfer within the company for advancement or just a change in environment. This could benefit the company in a couple ways. A transfer keeps the skill and corporate knowledge within the company and the individual has new and refreshed motivations. For the facility department, this gains a "facility expert", or at least a sympathizer, outside the department, and could bring in new perspectives for the operators. This can short-fuse many problems that could come to the facility trouble desk. It may cause short term problems in manpower, but it now may be manageable and improve the loyalty between employees and the company.

The emphasis here is that some of the goals can be beneficial to everyone, if they are known and acted upon. No goal will be achieved if left un-explored. Establishing goals is very important to an individual and to the organization. The goals should be both short-term and long-term, with milestones in between. This can provide the leader an excellent tool for developing communication, commitment and measurement for performance. Reward systems or incentive programs not tailored to the individuals they serve will be far less effective.

2.3.4 Counseling and Appraisals.

Counseling and appraisals may be one of the most difficult aspects of leadership. Establishing those elements above may resolve much of the difficulty in this area. If you take the time to know your people and their goals, establish clarity of the mission and vision and open the door for improved communication, the counseling process may still be challenging but may also be rewarding. It offers leaders the opportunity to assess their own success and charisma to achieve their goals and objectives.

An important part of the leadership process is evaluating the entire department, its mission, and the people. Far too often supervisors and managers fail to ensure the responsible parties receive credit for new ideas and contributions. Generally this is from fear of losing their own credibility and expert status, maybe even their job. If management is driving this fear, it will stamp out creativity, innovation, diminish productivity and create a very disgruntled work force. A good leader should know that the work force and department is a direct reflection of the him/her. The better the department looks and

performs, the better the leader is perceived. The focus, though, must take on a team concept. Although individual successes are valuable and possibly rewarded, every member in the department is needed to make possible the successes. This takes teamwork, loyalty, commitment and trust -- the essence of leadership.

This philosophy should provide confidence and satisfaction to promote harmonious relations with a rewards and positive appraisal system that eases those unfortunate situations where corrective action is required. Positive counseling and actions are almost always possible, focus must be on the process, the training, education, and tools provided for the successful performance with known expectations and goals (18). Fair and accurate appraisals must always be given to employees. The importance of fair and accurate appraisals should not be overlooked. False appraisals, or inflated evaluations, destroy the system. Using inflated marks fails to correct substandard performances and demoralizes the other employees.

CHAPTER 3: BUILDING SYSTEMS.

3.1 Introduction.

Proper building or equipment diagnostics is essential in avoiding expensive and misguided repairs and changes. The wrong diagnostics resulting in additional rework can be very disruptive to the work environment and customer satisfaction. This chapter presents building systems and equipment with the most direct impact on the organization. The discussion in this document is only an overview of the systems with a few potential references for further research and consultation. In assessing any facility problem or deficiency, the diagnostics is critical. Applying good communication and TQM to the problem will provide the best chance for proper diagnostics. Always ensure the occupants of the building and maintenance personnel are interviewed for details about problems. Ensure the problem is properly defined and good root cause analysis performed to avoid embarrassing and costly mistakes. The FM must keep on constant alert for new technologies and advances in buildings and its equipment to maximize the limited resources available. Partnering with local lighting, utility, and air conditioning companies, just to name a few, can help tremendously. Staying in touch with other professionals and related associations will also be helpful.

3.2 The Building Envelope.

The follow paragraph provides an excellent summary of the building envelope.

"The building envelope is the combination of systems that keep weather out of the building and the conditioned environment in the building. The envelope is required to resist a wide variety of forces, control water and air infiltration, reduce noise levels,

provide energy efficiency and accommodate the differential movement of its various components. It must also look appealing and be durable. Your building's envelope is expected to do a lot often without much maintenance. The various elements that make up the envelope - roof, skylights, walls, window, doors, and waterproofing – form a complicated system whose multiple parts have to function in concert against the hostile environment of sun, wind, rain, pollution, and freeze-thaw cycles.

- Jeffrey Brouillard and Kevin Cash 1997 (19:4)

3.3 Lighting.

The lighting systems of today are dramatically improved over previous years. Lighting technologies may be advancing faster than any other building system. The impact on lighting in our life is phenomenal, day and night, at work, in the home, in stadiums, on the roads, and at airports. Lighting has a physical and a psychological effect. In fact, lighting can have a profound effect on people's emotions and how they respond to an environment. Good lighting has the power to enhance the appearance of decor, furniture, artwork, merchandise and even people. The wrong lighting can have the opposite effect. (20) With the rapid advances in lighting it is vital to perform periodic investigations and relamping strategies to ensure the optimum environment and the most economical systems. Through lighting strategies, improved productivity and comfort can be achieved while reducing utilities and maintenance costs.

Several definitions are important to understanding and evaluating lighting systems. Color temperature, measured in degrees Kelvin, describes the psychological impact of the appearance of the light source. If the source appears blue it is cool and warm if red/orange/yellow. Color rendering index (CRI) is the appearance of color from an object under a light source as compared to other light sources. A CRI of 80-100 is considered a

light source with good color properties, but does not guarantee any specific color will appear natural. If one of the colors is missing in the light source that color will be rendered dull on objects. Lumens is the measure of a light source's output of useful light. The "efficacy" is the ratio of the number of lumens it produces to each watt of power it consumes. In today's energy conscious world, a lamp's lumens per watt (LPW) performance is one of its most critical characteristics. Service life is defined as the point in time when 50 percent of a large sample of those lamps will fail. Foot-candles measures the illuminance or amount of light per unit area that falls on a surface. This can be written into lighting specifications. Candlepower measures the intensity of a light source in a specific direction. A table of recommended light levels is shown below: (21)

Recommended Light Levels	
Type of Activity/Environment	Range of Acceptable Candlepower
Public space with dark surroundings	2-3-5 foot-candles
Simple orientation for short, temporary visits	5-7, 5-10 foot-candles
Working space with occasional visual tasks	10-15-20 foot-candles
Performance of visual tasks on material of: ■ High contrast or large size ■ Medium contrast or small size ■ Low contrast or very small size ■ Low contrast or small size for prolonged periods	 20-30-50 foot-candles 50-74-100 foot-candles 100-150-200 foot-candles 200-300-500 foot-candles
Performance of very prolonged and exacting visual tasks	500-750-1000 foot-candles
Performance of very special visual tasks of extremely low contrast and small size	1000-1500-2000 foot-candles

Table 1. Recommended Lighting Levels.

There are three major types of electrical lighting -- incandescent/halogen, fluorescent and high intensity discharge. Incandescent light is the most common lamp used in homes

and most people consider it to be "normal". The low temperature and high CRI casts a warm light which provides excellent color rendition of human skin tone. Unfortunately, incandescent lamps are inefficient, but are affordable. Tungsten Halogen lamps, tungsten filaments with halogen gas, are a refinement of incandescent technology that offers up to 20 percent greater energy efficiency, longer service life, and improved quality -100 CRI. Fluorescent Lamps basically excite the mercury vapor inside the lamp which causes the phosphor coating to "fluoresce". A ballast is required to regulate and reduce the current after high voltage surges needed at startup. The fluorescent lamps have very high LPW and are offered in a variety of color quality temperatures with outstanding color rendition of virtually all colors. High intensity discharge lamp technology includes mercury vapor, metal halide and sodium lamps. The high intensity discharge lamps basically operate like the fluorescent, but are under high pressure and require several minutes of warm-up time. The table on the next page describes the lamp characteristics. (22)

Lamp Color Characteristics		
Light Source	Characteristics	Effect on Color
Incandescent	Warm, inviting light, relatively inefficient	Brightens reds, oranges, yellows. Darkens blues, greens
Tungsten Halogen	Brighter, whiter light and more efficient	Brightens reds, oranges, yellows. Darkens blues, greens
Fluorescent	Wide selection of phosphor colors and temperature, highly efficient and long life	Depends on temp/CRI, highly accurate color reproduction lessens efficiency, more expensive
High Intensity Discharge (Metal Halide)	Whitest, most natural HID lamp, choice of color temperatures, extremely efficient, very long lamp life	Adequate CRI
High Pressure Sodium	Highest energy efficiency and longest life	Poor CRI, imparts orange-yellow color
Mercury	Extremely efficient and long life	Poor CRI, imparts blue-green color

Table 2. Lamp Color Characteristics.

The need for improved lighting comes from two areas, energy conservation and improved work places. The lighting systems can be custom tailored to meet the application of a corporation. The light sources should be designed with the reflective qualities of the walls, floors and ceilings, the amount of natural light available, the glare on computer screens, the hours of operation, and the maintenance strategies. A good maintenance strategy with programmed replacement and cleaning cycles is very important to maximum efficiency and effectiveness of lighting. Simple lighting improvement strategies can easily save thousands of dollars per year.

3.4 Heating and Air Conditioning (HVAC).

This section provides the basic principles of heating and air conditioning. Every FM knows that outages in HVAC systems will aggravate the occupants of a building faster than any other building system. The people are not the only concern, many systems are sensitive to temperature and humidity. One of the most difficult problems with the HVAC is the growth and changes of an organization. The original design of the system may not be capable of handling additional loads. This must be seriously reviewed during design to maximize flexibility in the facility without adding huge operating costs for over-sized systems. The FM and designers must thoroughly review the design and consider numerous space plans and growth options of the organization.

The factors to consider in HVAC includes, but is not limited to the following (23):

- inside loads - temperature and humidity requirements
- the envelope design and insulation properties
- the exterior environment
- building orientation
- noise levels of the HVAC
- building pressurization
- HVAC plant locations
- zoning strategies

The size and location of the ducting used must be with matched to the construction, under floor crawl spaces, above ceiling and riser sections between floor levels. The other major consideration is system choice, air-cooled, water-cooled, self-contained, cooling towers, chillers etc. Design and selection of a system should also consider maintenance, and maintenance and operating costs. One last impact to HVAC systems and design, is the new environmental regulations and inside air quality standard (24). The amount of fresh

; critical to the safe and enjoyable air quality of the occupants. Unfortunately, higher
mes of fresh air can require much larger and more expensive systems.

The manufacturers of HVAC systems can provide checklists and estimating sheets to
n specific designs like appendix A (25). The following presents a very basic
:ription and function of a large industrial system that was used in Hawaii. The system
l a cooling tower, chillers, and pumps to provide chilled water to air handlers inside
facility. The chilled water is returned across the cooling tower to remove excess heat
)re entering the chillers where it is super-cooled then pumped back to the air handlers.
the air handler, the chilled water cools air pulled from the return vents mixed with
h air and vents it back to the supply vents in the rooms.

Emergency Power (Uninterruptible Power Supplies and Diesel Generators).

h the advent of the computer age and the elaborate systems of today's facilities, most
anizations have become dependent on clean and dependable power. Power
:tuations and outages can cost thousands of dollars or more in lost revenues from data
ruption and lost files on computers. The life and safety of the occupants and the
ipment is also crucial during potential power problems. All hospitals and major
dical centers, communication stations, and key military facilities have some form of
ergency power. Understanding the system, and ensuring the readiness of a emergency
ver system is an absolute must for the facility manager.

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directly related to faulty maintenance. Risk analysis should be conducted on this aspect for consideration to outsourcing for the maintenance.

3.6 Telecommunications.

Telecommunications may be handled by a separate department in many organizations. This section describes new technologies emerging in the "telephone" industry. New systems called "key" systems offer fantastic savings and advantages to a company. The key system is basically a telephone system that uses the same technology of a computer LAN system. These key systems are offered by most telephone and communication companies. The major advantage of a key system is that outgoing telephone lines can be reduced by more than 70 percent. Instead of routing each outgoing line to a designated phone, all lines are routed to the key system and new phones are installed. All phones, fax machine and modems are connected to the key "server" and all lines can be shared. One headquarters facility with 150 staff members and 120 telephone devices, reduced the requirement from 110 outgoing lines to less than 40, with no problems experienced. With an average charge of $20-30 per line, the annual savings can be significant. In addition to the savings, voice mail, group conferences, call forwarding, and intercom services are possible. The system can pay for itself in less than three years. Another major advantage is when relocating or expanding an activity with inadequate phone services. The key systems can exceed existing and new demands, and avoid major costs in upgrading the telephone network.

3.7 Fire Protection and Security Systems.

Fire protection systems are now part of every facility and usually fall under the responsibility of the FM. In many cases, the security systems fall under the FM, but may have a separate security manager. The fire protection systems vary in technology and equipment. The typical equipment includes smoke and fire sensors, audible and electronic transmitting alarms, sprinkler heads and piping, portable fire extinguishers, and emergency lighting. In aviation hangar facilities, the system uses fire suppressing agents causing significant environmental concerns.

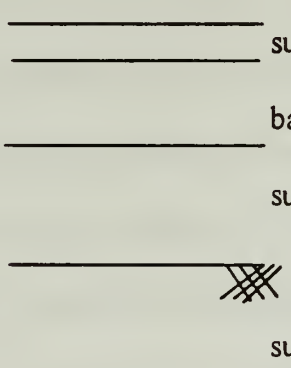
The basic operations of a fire protection/sprinkler system is as follows. Typically the sensors sound the alarms and activate the flow of the fire fighting agent to the sprinkler heads. Manual pull stations also provide the means to activate the flow. The systems can be dry or wet. Dry indicates that the pipes are charged with air instead of the fire fighting agent, typically water, and requires a precharge pump for pressurizing the lines with water. In most cases, the sprinkler head have a wax seal which melts under high temperatures to allow water to enter the spaces. The temperature to melt the wax seal usually must exceed 120 degrees Fahrenheit. Shutdown after activation is usually controlled by the Fire Marshall from the local Fire Department.

The are a vast number security systems available. The basic system includes magnetic door sensors, cameras, card readers, and computer monitoring equipment. The security program/system should include keys, locks, safes, lighting, clear zones and fencing. If a security system is used, a badge system is usually used to identify employees, vendors,

maintenance workers, contractors and visitors. Back-up and stand alone power usually is required.

3.8 Flexible Pavements.

Flexible pavement is just as important as those previously discussed. For the FM running a large plant with multiple buildings and roads, or a city manager, this can be of vital interest. The roads and parking structures impact the customers, the employees, and all shipment of goods to and from the facility. The flexible pavement typically consist of three layers as shown below:



The primary purpose of a flexible pavement structure is to protect the sub-grade and provide an improved transportation system. The design and maintenance of a pavement structure is theoretical and complex. Understanding and calculating the exact relationships of the tension and compression from all of the forces such as the climate, age, traffic loads and material composition - modulus, is not an exact science. Numerous test studies and models are used to predict the serviceability of a pavement structure. The AASHTO road test performed in 1960 provided probably the most widely accepted

formulas and prediction methods for design. As an overview only some of the major factors are presented with respect to the structural layer.

a) Sub-grade: the sub-grade effective modulus (psi) - accounting for drainage and reaction/responses to the compressive and tensile stresses applied from loads.
b) Sub-base: the modulus of materials selected with respect to protecting the sub-grade and the same characteristics above.
c) Grade: the modulus of materials selected with respect to protecting the sub-base.
d) Surface layer: the HMA mixture selected provides the smoothness and skid resistant surface for the traffic load, and a water barrier for the layers below.

The overall structural design is based on a structural number designed to protect the sub-grade and meet the desired serviceability, load and life expectancy. The surface layer modulus is important with respect to protecting the lower layers by resisting cracking and rupture and water infiltration. The best pavement design provides and good thick firm base layer to support the surface layer and protect the sub-grade. The sub-base layer protects the sub-grade and supports the surface layers by providing good drainage, stability and elevations where required. Other factors must be considered such as load transfer characteristics, the overall reliability and predicted loads. All of these factors are combined to calculate the required thickness of each layer. The economics, politics, and availability of the materials can significantly impact the design as well. For example, good strong crushed rock and gravel bases from the northern regions are much better than some of the limestone found in the south. Developing adequate designs for a good pavement structure is as much an art of prediction and modeling as it is a calculated

science. The only other major factor in pavement structures to keep in mind is, like any maintenance action, maintenance and repair must occur early on if defects are discovered. Repair costs to pavement structures will escalate exponentially if left untreated, good design with a vigorous maintenance and repair program will save millions of dollars over the life of a pavement structure.

CHAPTER 4: FACILITY OPERATIONS.

4.1 Introduction.

Knowing the basic systems in chapter three is important, but knowing the daily activities and operations of the facility is just as important. A strategic plan must be developed to maintain the flexibility and responsiveness of the facility department. The operations must include the maintenance and repair activities, all construction/alteration projects, and the daily operations. This chapter highlights some of the daily operations crucial to the smooth, safe and reliable environment of the facility. These include space planning, custodial services and grounds maintenance, energy management, physical security, and disaster preparedness. Facility maintenance is presented in the next chapter.

4.2 Space Planning.

More than any aspect of the FM mission, space planning seems to best follow the theory that change is the only thing constant. With elevated churn rates - turnover of personnel, new equipment, furniture and technologies, the allocation of space is never ending. Space is an extremely valuable commodity in expanding and dynamic companies. Churn rates usually are elevated with dynamic activities (27). Having a strategic plan that predicts the expansion and growth of activities is imperative to good facility utilization. Important aspects of space planning include the physical space available, the HVAC limitations, life and safety codes, American Disabilities Act, and special requirements - power, lighting, clean rooms, plumbing, etc.

The most important steps in space planning is accurately forecasting and programming space requirements. Before this can be accomplished, an accurate inventory of current space is required and square footage standards must be established. Numerous standards are available with recommended square footage allowances for people, equipment, furniture, and activities. The FM must find what is best suited and acceptable to the organization. One major problem of space management is that of who controls the space. If the FM controls all of the spaces, the job can be difficult, but if the line managers control the space, it can be far more complicated. Control and allocation can be lost in a world of turf battles. In either case, adopting a standard is crucial and must be supported and enforced at all levels of the organization.

A major aspect of space planning is new system furniture and computers. The new office furniture and computers have revolutionized the utilization of facilities. Although more expensive, system furniture and systems walls are extremely beneficial to the FM. This allows the immediate reconfiguration of an space without the need for physical alteration of the structure itself. In addition, the systems furniture can include conduit and wire runs to provide power, lighting, and data communication. If the FM can encourage the maximum open space design and systems furniture during design, space planning and flexibility will be dramatically improved.

4.3 Custodial Services and Grounds Maintenance.

Custodial services and ground maintenance are important both for the improved life cycle of the facility and the physical and psychological impact to the occupants and the

customers. The cleanliness is important for safety, security, health, and appearance of an organization and it's employees. The custodial services can also provide valuable information to the FM and identify building discrepancies and needed repairs. An aesthetically pleasing and clean environment promotes productivity. Furthermore, if the spaces are clean, people may take better care of their surroundings, reducing damage to equipment and the building.

Grounds maintenance is also important. It helps offset custodial demands and improves the physical security. Good vegetation and pavement/concrete structures can control water run off which reduces mud and dirt from being tracked into the building, and water intrusion into the foundation. The responsibilities of custodial services and grounds maintenance cannot be overlooked, they provide the organization with the improved environment and customer appeal. The appearance and condition of the facility is a direct reflection of the organization and it's people.

4.4 Energy Management.

The Energy Policy Act (EPACT) of 1992, mandated new improved energy efficiency throughout the United States. It significantly impacts facility management. In 1992, U.S. businesses spent more than $71.8 billion on energy consumption for commercial buildings (28). The utility cost is only one aspect of EPACT, EPACT requires new building codes with new and more expensive equipment and materials. The need for EPACT is clear, but the impact is significant.

An excellent energy management plan can be one of the best programs for the FM. Good energy programs reduce operating costs of utilities, waste management, maintenance, and enhance the work place. The program can provide great public relations between the facility department and occupants of the building. Support gained from this program can be transferred to other areas of facility management.

In deciding what energy conservation projects to implement, each should be prioritized by pay back periods and impacts on the organization. Shorter pay back periods alone are not always the best projects, public relations and enhanced physical work places must also be considered. The best place to start may be lighting. As much as 20 percent of a company's electric consumption goes to lighting, and the recent advances in lighting technologies make real savings possible. Reviewing lighting levels and working with building occupants may result in improved productivity and savings, as was found in the Hawthorne study (29). Air conditioning should follow lighting for review of the following (30):

- studying the balancing and maintenance
- thermostat settings and programmable thermostats
- taking better advantage of natural cooling and heating periods
- better insulation and reflective qualities on the building envelope
- sealing ductwork
- and possible thermal draft improvement at doors and exits

Numerous other areas in the facility can be researched for possible savings. According to a survey conducted by IFMA, 50 percent of capital investments in energy efficient

systems have seen a pay-back on investment in 18 to 36 months (31). Every effort should be made to partner with local utilities for possible incentives and assistance. The amount of information for energy saving tips is enormous. The National Renewable Energy Laboratory places tips on the home page on the Internet, http:exemplary_buildings@nrel.gov.

4.5 Physical Security.

The physical security of a organization can take on several forms. These include the security of the employees, damage or theft of equipment, sensitive or classified information. The first line of defense is the physical environment. Next, the employees must be informed and trained. A loss prevention program which includes inventory, reporting procedures and corrective actions must be developed. The program must focus on prevention to be effective. A risk analysis should be conducted at a minimum of annually to assess what the threat levels are, to what areas, the impacts, and protective measures required.

Every organization has a responsibility to it's employees to provide a safe and secure environment in and around the work place. The threat can come from hazards in the work place, the equipment, physical exertion, other workers or people outside the organization. The Occupational Safety and Health Agency (OSHA) provides outstanding guidelines and requirements for a safe work environment, but it is up to the employees and management to ensure that the standards are maintained. Training programs and TQM can help in resolving additional hazards in the work place. One key to improving the

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security of the personnel and the equipment, from intrusion or attack, is good grounds maintenance with proper lighting and clear zones. As an example, for areas immediate adjacent to and surrounding a facility, the military has set guidelines to the exact height and distances of objects, plants and equipment such as vehicles. This philosophy should be applied by business in regards for personal safety and for the building protection.

The threat on the equipment may be more from employee damage or theft. Good inventory control, loss prevention awareness and key control can help. Employee satisfaction may be the single most factor to help in reducing employee theft. The next best precaution is to ensure proactive steps to make theft difficult and visible. Crooks will be crooks, regardless of what you do and you probably cannot change them, but a good loss prevention program can help with awareness of losses, reporting procedures and visibility. Regular rotation and replacement of keys and door handle cores can control accessibility to areas, especially in a business with high churn rate.

Informational security can be organizational or personal. The personnel files should always be protected. The threat analysis for informational security should indicate additional measures beyond those of locking cabinets and safes. Changing of safe combinations should take place after employees are separated and at regular intervals. The FM should be familiar with the details of the various systems and their locations. All of the physical security measures impact the FM. Providing escorts for contractors and visitors can be costly and time consuming for the organization and the FM. There can also be direct financial implications if access for systems and repairs are restricted to after hours and limited hours during the day.

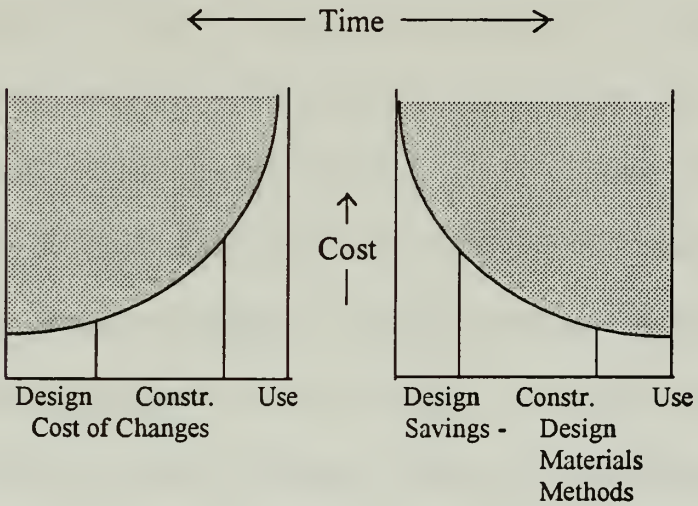
4.6 Disaster Preparedness.

Disaster preparedness is only successful if done in advance of the disaster. No greater threat can come to a facility than natural disasters. With the disasters in recent years; fires, earthquakes, floods, hurricanes and tornadoes, every business should have a plan. There are very cheap and easy preparations that can be taken to minimize the amount of damage that may occur. The local and federal disaster agencies can provide valuable information in preparation checklists, materials, critical timelines, and actions. Each facility should have a disaster locker set up for emergencies. The locker should include simple tools like hammers, portable tools (battery powered), flashlights, sand bags and lumber to name a few. The actions of a business may be futile in a major catastrophe, but for the near misses, thousands or hundreds of thousands of dollars in damages can be prevented.

CHAPTER 5: MAINTENANCE STRATEGIES.

5.1 Where maintenance begins.

The most important phase of any project is at conception and design. Changes during design are generally free or very little cost, and become exponentially higher as the project moves forward. The two graphs below perfectly illustrate the cost relationship of making changes during the life of a project.



"The decisions made in the conceptual and schematic phases have the greatest impact and the least cost commitment."

- Larry Gleason, "Modeling Facility Construction Alternatives," IFMA Conference, 1987 Proceedings

Maintenance must begin during the planning and continue through every phase of the project.

"Maintenance departments often see and begin to have input into equipment life-cycle care only after it has been selected, installed and turned over to the facility for commissioning and subsequent operation. Starting at this point, 95 percent of the total maintenance burden of the equipment or system has been fixed, leaving only a small opportunity for the maintenance department to influence the effectiveness of the

equipment care. Many equipment selections are based entirely upon costs by persons following a list of specifications that usually do not include maintenance considerations. Therefore, the less expensive selection may, in the long run, be considerably more costly for the facility and a large headache for the maintenance department."

- Life Cycle Engineering (32:2)

5.1.1 Design Phase.

The design phase is the most critical phase to getting all of the information and facts together to facilitate the best and most cost effective project. The cost benefit analysis during design should clearly indicate the associated costs in materials and labor, and any expected downtime impacts. It is imperative that the facility department, the maintenance technicians and end users be actively involved during all phases. It is not enough to just review plans and specifications, far too often the intent of the design is lost during another phase with a change, or something is overlooked the leaves the maintenance crews with unreasonable expectations to perform their tasks. Examples of this can include inadequate space or access to a piece of equipment. Meeting the specification may occur, but practicality may be questionable and only the end user may see this and be forced to live with the consequences.

5.1.2 Construction Phase.

The construction phase, like the design phase, must have the facility management department actively involved. Inevitably there will be difficulties during construction which can lead to changes in equipment and materials that on the surface seem adequate.

Having the maintenance personnel and operators involved can avoid costly changes later on and the personnel can gain invaluable information about the systems and equipment.

Prior to construction, establishing "rules of the road", is an essential element to avoiding the traditional adversarial roles between the contractor, owner, and the architect. Spending time to clearly establish the "rules of the road" can drastically improve the relations. Scheduling constraints, noise restrictions, and expected dress codes may seem trivial to the owner, but can have a direct impact on the contractor. These details should be discussed in depth prior to commencement of work.

5.1.3 Building Occupancy and Maintenance.

The "use" phase may be the least glamorous for some, but it is this phase that the systems and equipment all come together to accomplish their set design. Changes in this phase are usually very expensive and can be disruptive to the facility and its occupants. Thousands of dollars in maintenance activities can be avoided by the corporate knowledge gained during design and construction phases. Unfortunately, most facility departments are not established prior to or during the design and conception phases of major facilities so they cannot actively participate in those phases.

5.2 Maintenance Strategies.

"Today's economic and competitive environment requires industry sustain full production capabilities and minimize capital investment. From the maintenance perspective, this means finding ways to maximize equipment reliability and up-time, and extend plant and equipment life through cost effective maintenance. To achieve these objectives, industry must move away from the traditional reactive maintenance mode to proactive maintenance and management philosophies. Maintenance processes that fully

address the program and technical concerns of maintenance must be adopted and the process must realize the value of integration, engineering, planning and quality."

- Life Cycle Engineering (33:1)

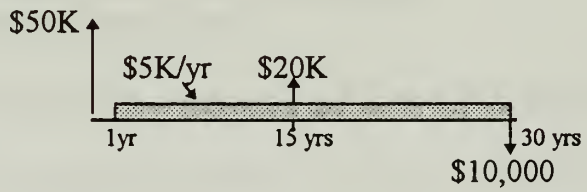
The traditional approach of planned maintenance (PMS), or scheduled maintenance, is well established and understood. The need for PMS is also well understood, it ensures that the optimal operations can meet or extend the manufacturer's stated life cycle. Advantages of this system are fixed times and costs, ease of scheduling with maintenance decks and checklists, and streamlined personnel training during turnover. The main disadvantage of this system is that it may not provide the best total value and forces maintenance activities that may be unnecessary. New and innovative strategies must be employed to take better advantage of emerging technologies and methodologies. One of these is reliability centered maintenance.

The reliability centered maintenance (RMC) approach provides a detailed probability and risks analysis. It takes into account the probability of failure, the criticality of the impact, and all associated costs. This approach can streamline the maintenance activities and remove long labor-intensive maintenance procedures. Assuming a shorter life in many cases also provides earlier windows to purchase and install newer potentially cheaper advanced technologies. Careful evaluation of the advantages and disadvantages can make the selection of which strategy, or combination of them, that can lead to a very aggressive and proactive facility department.

One effective tool for evaluating the projects, equipment selection and maintenance options is life cycle costing (LCC). The best decision on which choice is made considers

the total cost of ownership and not just the initial investment. Operating and maintenance cost over the long life of a building or system can far exceed initial costs. Some of the factors are initial investment, operating and maintenance, efficiency and life expectancy. To be accurate, a detailed analysis must take place on the operations and maintenance, and the efficiency. Far too often these areas are underestimated and leave out critical elements. Such items as special tools, special material handling costs, supporting functions and spaces, have a direct and indirect impact on the productivity with possible failures and maintenance outages. The advances and higher efficiency of rapidly changing technologies must be considered. The following example provides a LCC model of an HVAC system using the present worth method:

Initial Cost:	$50,000
One-time replacement at 15 years:	$20,000
Annual Operating costs:	$ 5,000
Salvage value after 30 years:	$10,000
Discount rate:	10 %



Total Present Worth = $50,000 + $5,000 x (UPW;30,10%) + $20,000 x (SPW;15,10%)
- $10,000x(SPW;30,10%)
= $50,000 + $5,000 x 9.42691 + $20,000 x 0.23939 - $10,000 x 0.05731
= $101,349.25

UPW = Uniform Present Worth $= \frac{(1+i)^n - 1}{i(1+i)}$

SPW = Single Present Worth $= \frac{1}{(1+i)^n}$

n = years, i = interest rate

Developing a similar model with an alternative HVAC system and it's costs, provides a clear method for best choice over the life of the systems. There are other methods besides the present worth method, but as long as the formulas are correctly used the same conclusions should be reached. Using this method helps illustrate the costs and, if the RMC comparison is used, side by side comparisons can easily be viewed and evaluated. It is important to account for the increases in environmental regulations and the associated potential costs. (34)

Another tool the FM can use to streamline the department is outsourcing. Instead of maintaining large in-house forces, specific functions can be contracted out to specialized firms. Various factors must be considered before using outsourcing including:

- maintenance planning, repair parts
- consumables
- special supplies
- special test and support equipment
- special materials handling requirements
- operations and maintenance personnel training
- data and processing management

Often companies can provide services cheaper than a large facility department, but there are some important management aspects to consider. The level of quality, responsiveness, new year bid-price increases, and the visibility and interface of the building occupants with the FM department. There is additional risk with outsourcing. Rapid changes in the market with competition and pricing can leave a facility with enormous fluctuations in annual maintenance costs. Reverting back to in-house functions usually cannot meet these changes as they occur. Through all of this there is concern of losing corporate knowledge of the facility and the equipment.

For in-house strategies, the maintenance force and structure must be dynamic and proactive. The most important factor is that the FM should not be more than two levels from the senior company executive (35). From personal experiences, one good model of a facility department is a centralized office model in which the FM, the work center, purchasing, and production supervisor are co-located. The central location allows constant communication and with good visual status boards for maintenance and projects, making immediate assessment of the department possible.

One example of a facility staff supporting an military operational command and communication facility is as follows:

- the FM
- one carpenter
- two multi-skilled HVAC and plumbing specialists
- three electricians - an electronic device specialist, a general electrician, and one multi-skilled emergency power generation and UPS specialist
- one work receptionist
- one project manager
- one laborer

The two story, 200,000 square foot facility supported 500-600 personnel. The facility had dozens of offices and work spaces, several complex communication/data processing centers, and additional warehouse spaces. Each of the communication/data processing centers required special raised computer flooring, electrical distribution and power, HVAC, and security/fire protection systems. Three service contracts were used for the HVAC, emergency power generation systems, and security/fire protection systems, and one general maintenance contract for major repair projects. This model and mix of

strategies provided a well balanced 24-hour support team with immediate response capabilities.

Another effective model used by Shands Hospital is a zone maintenance plan. The zone maintenance personnel were physically located in their respective "zones". This provided daily interaction with the customer and the maintenance of the spaces. This strategy was a fantastic success for the hospital. (36)

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS.

The facility management profession is rapidly expanding. The new associations and educational programs offer significant opportunities to facility professionals for creating innovation and proactive strategies to accomplish the mission. The application of TQM programs combined with the national and international standards can assist in creating a leading edge facility management team. Advice would be to use the TQM ideas and analysis, but avoid "Paralysis by Analysis" (37:388). The investment of time and energy into developing improved leadership and communication skills is paramount to successfully achieving any mission. One recommended reading, outside those in the bibliography, is IS GETTING PAST NO NEGOTIATING WITH DIFFICULT PEOPLE, by William Ury. The need for strong leadership and skillful communication can help tremendously with the routine problems in the facility management industry.

The diversity of the two lists in chapter 3, demonstrate the tremendous challenges and responsibilities of the FM. The FM must be a leader, an engineer/manager, a business professional, equipped with extraordinary vision, communication and planning skills. Far too often the FM is not actively involved in the design process, but this trend must not continue. The cost benefits to ownership and enormous gains in corporate knowledge during the planning, design and construction cannot be overstated. Using the principles of life cycle costing, good value engineering, and new technologies, combined with innovative maintenance strategies including outsourcing, can make great strides toward a dynamic and proactive maintenance program. Outsourcing is a substantial benefit if done

correctly. The overall responsibility of the maintenance mission still rests with the FM, and so must the control. Whichever organization structure is adopted, centralized, decentralized or a zone maintenance structure, the focus must be on the customer's needs. The "us versus them" philosophy can destroy the effectiveness and motivation of the facility maintenance department and alienate customers.

With the enormous amount of diversity in the competencies that come with facility management, it is impossible to recommend one strategy that can be applied across the industry. There is, however, recommendations that may improve the facility manager. The first step is to become technically competent on the facility systems and operations, not an expert, leave that to the technical experts on your staff. The next step is to communicate with your people and the executives; establish base lines of performance, expectations and the needs of your people and customers. With this knowledge of systems, operations, and people; the processes that affect them should be organized and developed using one of the total quality management philosophies and standards. At this point, the various strategies can be developed considering the internal organizational capabilities and that of the local economy for outsourcing and contracted services. One benefit of outsourcing is that the transfer of services to an outside agency may free up the facility department to take on new projects and programs to enhance the facility and customer satisfaction. Those projects could include energy management, space planning, and aesthetic/functional improvements in the work place to improve quality of life and productivity. There is no one solution to improve facility management, each

manager/engineer must explore all of the options and capitalize on the rapidly expanding associations to build the best program.

"The ideal facility management program will be easily accessible to it's customers and exceed their expectations. The preventive and corrective maintenance, as well as repair and renovation activities should be transparent to the building occupants ... except to notice the facility improvements."

Jerry J. Shoemaker

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APPENDIX.

Job Name RESTAURANT	Job No.
	Date
No. and St.	Estimator
City Houston State Texas	Salesman

Size of Space 20 X 40	Inside Design Conditions:
Floor Area 800 Sq. Ft.	80 FDB Outside WB 78
Ceiling Height 12 Ft.	50 RH DB 95
Room Volume 9600 Cu. Ft.	Time of Peak Load 1 to 4 PM

COMMERCIAL AIR CONDITIONING ESTIMATE

RESTAURANT

Courtesy of Carrier Corporation

SURVEY INFORMATION

Record all information essential to the cooling and heating estimates, the air distribution system, and the equipment selection, location and installation.

DIMENSIONS OF SPACE

Sketch floor plan on Page 5, or obtain building plans. Indicate scale. Record all dimensions including ceiling heights, heights under beams, and floor to floor heights.

WALLS

Direction Facing	N-NE	E-SE	S-SW	W-NW
Construction	HEAVY	HEAVY	HEAVY	HEAVY
Insulation thickness				
Shaded	✓		✓	
Gross Area (Sq. Ft.)	480	240	480	240

WINDOWS

Type Shading				AWN.
Area (Sq. Ft.)	50			68
Net Wall (Sq. Ft.)	430	240	480	172

PARTITIONS

Area adjacent to unconditioned space ..... sq. ft.
Area adjacent to kitchen, boiler rm., etc. 240 sq. ft.

ROOF

Construction: (light) (medium) (heavy)
Ceiling (Yes) (No)
Insulation thickness 2 in.
Attic Space: Ventilated by fan (Yes) (No).

CEILING

Unconditioned space above — area ..... sq. ft.
Insulation thickness ..... inches

FLOOR

Unconditioned space below — area ..... sq. ft.
Kitchen, boiler room, etc., below — area ..... sq. ft.
Insulation thickness ..... inches
SLAB 800 SQ. FT.

ELECTRICAL

LIGHTS IN USE AT TIME OF PEAK LOAD (Note 1.)

Incandescent: 1000 watts or .. watts per sq. ft.
Fluorescent: ..... watts or ..... watts per sq. ft.

ELECTRICAL (Cont.)

MACHINES OR MOTORS (Note 5.)
Rating in Watts or Horsepower

APPLIANCES (Record in Table 3.)

PEOPLE (Note 1.)

Number in space at time of peak load: 24

OUTSIDE AIR FOR VENTILATION (Note 6.)

EXHAUST FANS (Table 4.)

TYPE	H.P.	DIAMETER (in.)	SPEED

POWER SUPPLY

Volts, 230 phase, 3 cycles, 60
Panel ..... ft. from unit.
Main switch capacity ..... amps.

CONDENSING METHOD

(City water.) (Cooling tower.) (Air Cooled.)
(Evaporative condenser.)

WATER SERVICE

Connection 5 ft. from unit. Size ..... in.
Water pressure ..... lb. New service, new meter.
Pressure reducing valve required? (Yes) (No)

CONDENSER WATER AND/OR CONDENSATE DRAIN

Distance from unit 5 ft.
Low enough for gravity flow of condensate? (Yes) (No).
New drain or condensate pump required? (Yes) (No).

HEATING

Steam pressure ..... lb.
Hot water temperature 140 F.
Capacity available: ..... (Btuh) (lb. steam) (gpm).
Connection ..... ft. from unit.
Connection size ..... inches.

EQUIPMENT LAYOUT

Show location of Weathermaker, ~~cooling tower~~, ~~air cooled condenser~~, pump, supply, return and outside air ductwork in sketch on page 5. ~~Verify construction where equipment weight is to be supported.~~

COOLING ESTIMATE

		TIME OF PEAK LOAD										Other Facings	Sq. Ft.	BTU/HR
		8:00-10:30		10:30-1:30		1:30-4:30		4:30-7:00		7:00-11:00				
	Facing	NE S	SE E	SE SW	S	NW S	SW W	NW SW	W	All Facings				
WINDOWS SUNLIT (Note 2)	No Shades	56	146	74	104	64	159	66	116	25		33	50	1650
	Inside Shades	34	84	48	64	44	97	44	32	25		27		
	Outside Shades	24	55	35	46	35	68	34	51	25		24	68	4624
	Glass Blocks	19	75	58	42	42	67	50	77	25		16		
	SHOW WINDOW PARTITION (Note 2c)	20												

												Multiplier For Insulation	Sq Ft (Net Wall Area)	
WALLS (Note 3)	Construction													
	Frame (U = 0.27)	NE-E SE	7	E-SE-S	8	SE-S-SW W-NW	8	SW-W NW	11	SW W NW	6	0.36 (U = .097)		
		S-SW-W NW-N	0	NE-SW-W NW-N	4	NE E-N	5	N-E S NE SE	4	N E S NE-SE	2			
	Light Masonry (U = 0.46)	All Facings	0	NE E SE	9	E-SE-S	9	S-SW W	10	S SW W NW	11	0.48 (U = 0.22)		
				S-SW-W NW-N	1	NE-SW W-NW-N	5	NE-E SE NW N	6	NE E SE N	6			
	Heavy Masonry (U = 0.35)	E SE-S SW-W	2	NE-E	4	NE-E-SE	5	NE E SE S-SW-W	4	SW-W	7	0.54 (U = 0.19)	1082	3246
		NE N NW	1	SE-S-SW W-NW-N	2	S SW W NW N	3	NW-N	3	NE E SE S-NW N	4			
	PARTITIONS (U = 0.40)	Unconditioned Space Adjacent				4						0.28 (U = 0.11)	240	3360
		Kitchen, Boiler Room, Etc., Adjacent (E)				14								

			Insulation (inches)														Sq Ft	
	Construction (Note 4)		0	1	4	0	1	4	0	1	4	0	1	4	0	1	4	
ROOF (Flat or Pitched)	LIGHT	Attic	9	5	3	16	8	5	16	8	5	11	5	2	3	2	1	
		No Ceiling	14	6	3	23	10	5	24	11	5	11	5	2	4	2	1	
	MEDIUM	Attic	4	2	1	10	6	3	13	8	4	11	6	3	5	3	2	
		No Ceiling	5	3	2	14	7	4	19	9	5	15	7	4	7	4	2	800 4000
	HEAVY	Attic	2	1	1	7	4	2	13	7	3	13	7	4	10	5	3	
		No Ceiling	3	1	1	11	5	2	19	8	4	20	8	4	15	6	3	

				Sq Ft	
CEILING	Unconditioned Space Above	Not Insulated	Insulated		
		3	1		
FLOOR	Unconditioned Space Below	5	2		
	Kitchen, Boiler Rm., etc., Below	15	6		

			Watts	
ELECTRICAL (Note 5)	Lights in use at time of peak load			
	Incandescent (3.4) / Fluorescent (4.25)	3.4	1000	3400
	Machines Rated in Watts	3.4		
	Motors	3200	HP	
APPLIANCES	Total From Table 3			4600
PEOPLE	At time of Peak Load	450	Persons 24	10,800

						Cfm	
OUTSIDE AIR (Note 6)	Inside Dry Bulb Temperature and Relative Humidity			Outside Wet Bulb Temperature			
				70F	75F	78F	80F		
		78F, 55%	80F, 50%	12	32	46	55	360	16,560
	76F, 55%	78F, 50%	80F, 45%	18	38	52	61		
	75F, 55%	77F, 50%	78F, 45%	22	42	55	65		
	75F, 50%			26	46	60	69		

52,240 BTU/HR GRAND TOTAL HEAT / 12000 = 4.3 TONS

GRAND TOTAL HEAT 52,240

TABLE 1 — CONDITIONED AIR REQUIRED (CFM/TON)

Application	Average Sensible Heat Factor	Room Conditions	Percent Outside Air Through Unit (Note b.) 0%	10%	20%	30%	Recommended cfm per person
Office	90	75F, 50% 77F, 50% 78F, 45% 80F, 45%	620 670 560 540	520 550 455 450	430 440 375 370	350 370 320 320	15
Apartment Hotel Room	83	75F, 50% 77F, 50%	560 600	450 475	365 385	300 330	20 30
Art Museum Bank Department Store Upper Floors Hotel Public Spaces Libraries	83	78F, 50% 78F, 55% 80F, 45% 80F, 50%	580 700 480 630	495 600 395 530	410 510 335 450	340 450 290 390	10 10 7½ 25 10
Barber Shops Beauty Shops Department Store Main Floor Dress Shops Hat Shops Men's Shops Shoe Stores	80	78F, 50% 78F, 55% 80F, 50%	520 670 540	425 550 450	360 460 385	300 400 345	15 10 10 10 10 10 10
Department Store Basements Drug Stores Five & Ten Stores Restaurants	.73	78F, 55% 78F, 50% 80F, 50%	360 500 415	305 410 350	270 350 310	200 320 280	10 10 7½ 15
Auditoriums Theatres	.70	76F, 55% 78F, 55% 80F, 50%	420 440 330	350 370 290	300 320 260	270 290 220	7½ 7½
Supermarkets	78	78F, 50%	490	400	340	290	10

NOTES

a.) Cfm ton values apply to calculated cooling load, not Weathermaker capacity.

b.) Percent Outside Air Through Unit = $\frac{360 \text{ CFM Outside Air} \times 100}{400 \times 4.3 \text{ Tons From Page 3}} = 20\%$

TABLE 2 OUTSIDE AIR QUANTITIES

WEATHERMAKER SELECTION

Conditioned Air: Tons (From Page 3)	×	Cfm Ton (From Table 1)	=	Total Required (cfm) (Note c.)	Model Number (Note d.)	Maximum Conditioned Air Capacity (cfm)
4.3		310		1333		

NOTES

c.) Total conditioned air required (cfm) = Tons (from page 3) × cfm/ton (from Table 1).

d.) Select Weathermaker on basis of required conditioned air capacity as well as tons of cooling capacity. When air capacity of unit is insufficient, inside conditions cannot be met. Change inside conditions or use larger unit.

COOLING ESTIMATE NOTES

1. TIME OF PEAK LOAD
   a) Small number of people. Select time when greatest window area is sunlit.
   b) Large number of people. Select time of peak occupancy.
2. WINDOWS
   a) Sunlit Windows. Use only those facings shown for time of peak load.
   b) For all windows use factors in "Other Facings" column.
   c) Show Windows. Use partition area; if no partition consider as ordinary window.
3. WALLS
   Heat gain values are proportional to transmission coefficient "U." Consider shaded walls as "North".
4. ROOF
   Use "No Ceiling" values only if underside of roof is exposed. Multiply values by .75 if attic is ventilated by fan.
5. ELECTRICAL
   Reduce ratings of machines and motors which do not run continuously or are not fully loaded.
6. OUTSIDE AIR QUANTITY
   a) Outside air through unit.
      1) No exhaust fans—Use Table 2.
      2) Exhaust fans—Use the larger value from Table 2 or Table 4.
   b) No outside air through unit.
      1) No exhaust fans—Use 7 CFM per person.
      2) Exhaust fans—Use value from Table 4.

TABLE 3 — HEAT FROM APPLIANCES

Item	Quantity	Gas Heated	Electric Heated	Btu/hr
Coffeemaker (Glass), ½ Gallon Each	1	1,700	1,200	1700
Coffee Urn — 12" Diameter		4,300	3,200	
—18" Diameter		7,600	5,700	
Electric Motors	HP	2800		
Food Warmer (Per Sq. Ft. Top Surface)	sq. ft.	1,300	700	
Fry Kettle — (3000 Watts)			4,500	
Griddle — (Per Sq. Ft. Top Surface)	sq. ft.	7,000	3,000	
Hair Dryer — Blower Type (1500 Watts)			2,700	
— Helmet Type (700 Watts)			2,200	
— Five Helmets		1,900		
Permanent Wave Machine (1500 Watts)			1,000	
Toaster, Savory (Automatic, 2 slices wide)		11,000	6,400	
Toastmaster, 2 slices (1225 Watts)	1		2,900	2900
Other Appliances (Note 3.)				
Total Heat From Appliances (Insert in Cooling Estimate Page 3)				4600

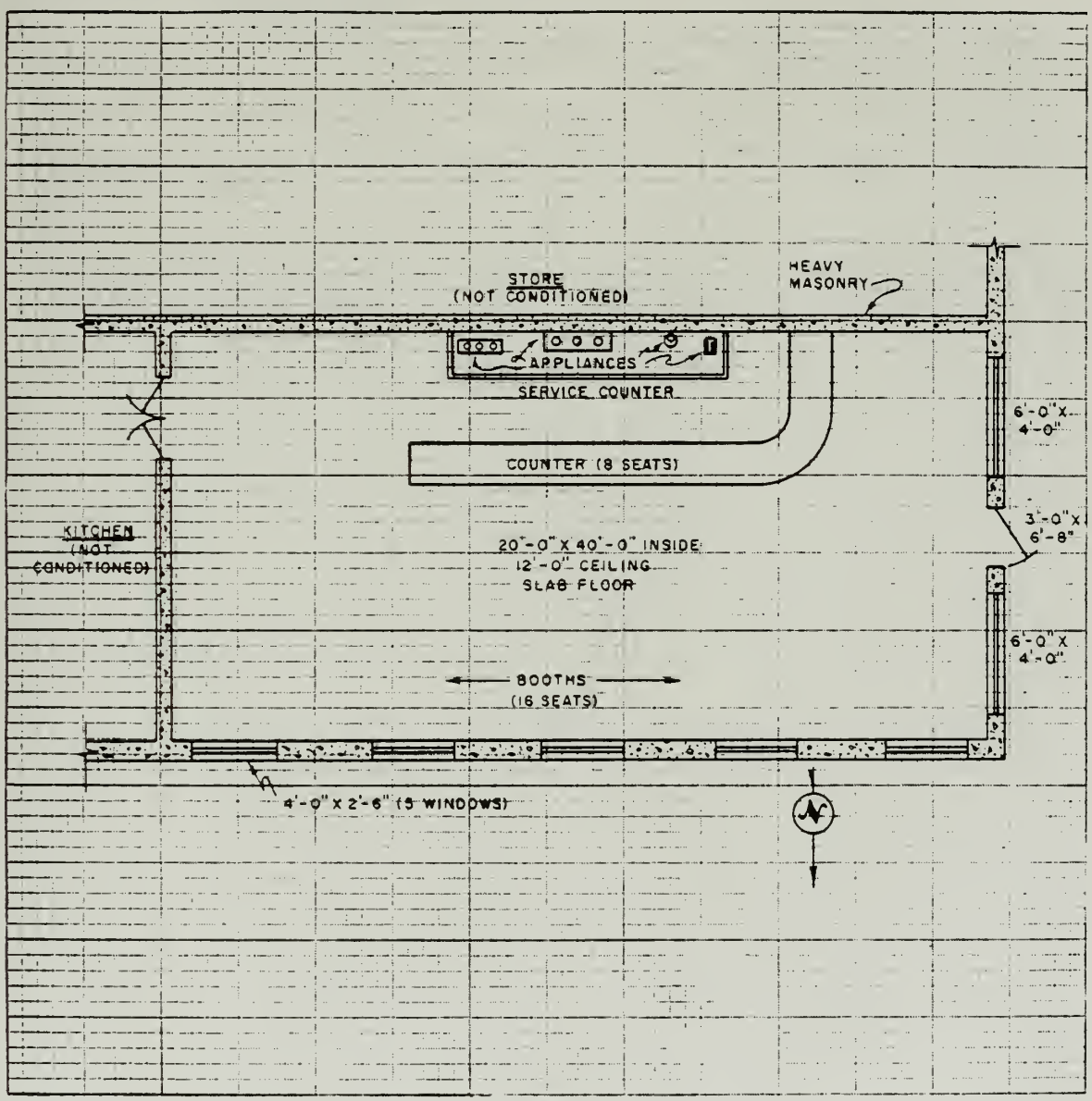
TABLE 4 — EXHAUST FAN CAPACITIES

Centrifugal Fans			Propeller Fans		
Inlet Diameter (Inches)	Air Quantity (CFM)	Motor Horsepower	Fan Diameter (Inches)	Fan Speed (RPM)	Air Quantity (CFM)
6	550	1/6	8	1500	500
8	1000	½	12	1140	820
10	2800	2	12	1725	1100
12	1600	½	16	850	1000
			16	1140	1500

Slight airway resistence can materially reduce the above capacities.

NOTES FOR TABLE 3

1. These are not maximum ratings, but are recommended for average usage.
2. Factors given are for unhooded equipment. Where properly designed hoods with exhaust fans are in use, reduce factors by 50%.
3. Use 50% of manufacturer's rating.



HEATING ESTIMATE

	ITEM	QUANTITY	FACTOR	Btu/Hr/Deg. Temp. Diff.
1. WINDOWS and INFILTRATION	Single	118 sq ft	(1.6)	189
	Double or Glass Block	sq ft	0.7	
2. DOOR USAGE	Light Traffic — Dress Shop, Shoe Store, Office, (Restaurant)	20 sq ft	(4.0)	80
	Heavy Traffic — Drug Store, Dept. Store, Cigar Store, Lunch Rm, Bank	sq ft	12.0	
3. OUTSIDE WALLS	Frame	lin ft	3.2	
	Light Masonry	lin ft	5.4	
	(Heavy Masonry)	60 lin ft	(4.2)	252
4. ROOF (flat)	Uninsulated, no ceiling	sq ft	0.50	
	Uninsulated, with ceiling	sq ft	0.33	
	(Insulated with or without ceiling)	800 sq ft	(0.13)	104
5. ROOF (pitched)	Horizontal ceiling uninsulated	sq ft	0.29	
	Horizontal ceiling insulated	sq ft	0.09	
6. FLOOR	Wood, over open space, i.e. porch	sq ft	0.24	
	(Concrete on ground)	60 lin ft	(0.69)	41
	Wood, over unheated basement	sq ft	0.17	
7. OUTSIDE AIR		360 cfm	1.10	396
			TOTAL BTU/(HR) (°F TEMP DIFF) =	1062

TOTAL HEATING LOAD = TOTAL BTU/(HR) (°F TEMP DIFF) 1062 × 70 °F TEMP DIFF = 74,340 Btu/Hr

NOTES

1. For DOOR USAGE figure area of entrance door.
2. For concrete FLOOR on ground figure linear feet of exposed edge.
3. For PITCHED ROOFS, use area of ceiling.
4. Deg. Temp. Diff is difference between room temperature and outdoor design temp.
5. To obtain lbs of condensate per hour divide the total Btu/hr by 970.
6. To obtain the Equivalent Direct Radiation (EDR) divide the total Btu/hr by 240.

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